Oscillations in Chromospheric Network Bright Points

D. Banerjee & J.G. Doyle

Armagh Observatory, College Hill, Armagh, BT61 9DG, N. Ireland

E. O'Shea

Dept. of Pure & Applied Phys., Queens University Belfast, Belfast BT7 1NN, N. Ireland

Abstract. We examine spectral properties of the solar chromospheric and transition region network from the SUMER instrument onboard SOHO. Observations were obtained for a number of lines ranging in temperature from Log T=4.1 K to 5.5 K. We concentrate on a network region and study intensity and velocity oscillations in two chromospheric spectral lines, observed simultaneously at O vi 1037.6 Å and C II 1037.2 Å. The 3.7 mHz intensity oscillations observed in O vi are often accompanied with a blue-shifted line profile of 3–5 km s⁻¹. These oscillations can be interpreted in terms of magneto-acoustic waves propagating upwards along thin magnetic flux tubes. Observations are compared with numerical simulations of waves propagating in a thin flux tube.

1. Introduction

Using SUMER, Doyle et al. (1999) have studied the intensity oscillations of two chromospheric lines N I 1319 Å and C II 1335 Å. They have looked for differences between the power spectra of network and internetwork regions, and searched for evidence of propagating waves by considering phase differences in the emission of these lines which are formed at different temperatures. O'Shea et al. (1999) have enlarged the scope of this type of analysis using different lines formed at different heights (from Log T= 4.1 K to Log T = 5.5 K) in the outer solar atmosphere. In this short presentation we concentrate on a typical network region. The results are compared with magneto-acoustic waves.

2. Observation

The observations were made for a quiet region, typical of both network and internetwork (cell center). The dataset analysed here was acquired from 15:47 UT to 16:25 UT on 30 July '96 at 6 arcsec West of disk center, zero arcsec North, using SUMER on SOHO. Two spectral lines were observed simultaneously, O vi 1037.6 Å and C II 1037.2 Å, covering 50 wavelength pixels (~2.5 Å) and 360 arcsec in the North-South direction. A full description of the Fourier technique can be found in Doyle et al. (1997). For line shifts, an average wavelength was derived
via summing the data along the entire slit (20 to 320 arc sec) for each data time-point. The spectral data were then fitted with a Gaussian for each spatial pixel at each data time-point.

3. Results

Oscillations were found at several locations along the slit and are not confined to the brightest areas (see Figure 1). Network regions can clearly be seen in Figure 1, at positions along the slit that remain persistently bright, showing (almost) as horizontal streaks. Oscillations were seen to occur in packets of about 10-40 minutes duration. The best example of an oscillation group is plotted in Figure 2, for the region 175-180 arc sec along the slit corresponding to a network. In this ‘quiet’ region dataset, the frequency of intensity oscillations is typically around 3.7 mHz, which corresponds to an oscillation period of \(~4.8\) minutes. These lines show velocity variations of 2-5 km/s amplitude with a spatial scale of several arc seconds. Furthermore we see clear evidence of blue shifts of \(~5\) km/s for the first 25 minutes period of observation.

4. Numerical Model

We assume that a pulse is generated by the foot-point motion of the magnetic flux tubes in the network boundary, and has a Gaussian velocity profile, and this is consistent with the observations of photospheric bright points associated with magnetic elements, Berger et al. (1998). We study the propagation of transverse magnetoacoustic (also called kink) waves within a thin flux tube
Figure 2. The behaviour with time of the intensity and Doppler shift of the O vi (solid line) and C ii (dashed line) lines. The plots are summed over spatial pixels 175-200.

embedded in a two-layer isothermal atmosphere. The displacements of the flux tubes at different heights for a particular maximum velocity of the foot-point motion, can be derived (see Choudhuri et al. [1993] & Banerjee et al. [1999]). Figure 3 shows the displacements of the flux tubes at the formation heights of
O VI and C II as labeled. The parameter space is characterized by dimensionless variables, $\alpha = h/4H_1$, the measure of the thickness of the first layer, where $h$ is the height of the layer in kilometers and $r = \sqrt{T_1/T_2}$, the measure of the temperature contrast between the two layers. The cut-off frequencies of the two layers are also related as $\omega_{c2}/\omega_{c1} = r$. We place the temperature jump around 2000 km ($\alpha = 2$) above the photosphere and the temperature contrast corresponds to the temperature jump in the transition layer. Whenever a pulse propagates through a stratified medium, it is known to leave a wake behind it oscillating with the cut-off frequency of the atmosphere. Note that the wake oscillates with a frequency which is neither the cut-off frequency of the lower layer ($\omega_{c1} = 12.6\text{mHz}$) nor the upper layer ($\omega_{c2} = 10.4\text{mHz}$). Instead it oscillates with a frequency $\omega = \omega_{c1} + \omega_{c2} = 23.0\text{ mHz}$. Thus this layer is oscillating with a cyclic frequency $\left(\omega/2\pi\right)$ of 3.66 mHz, which is similar to the observed frequency 3.7 mHz (see Banerjee et al. [1999] for details).

![Graph showing displacement of flux tube](image)

**Figure 3.** Displacement of the flux tube, at rough formation heights of C II and O VI lines as a function of time in units of cut-off frequency.
5. Conclusions

Our network observations suggest that the lower chromospheric intensity oscillations come from small regions (presumably magnetic flux tubes) of at most 5-8 arc sec along the slit and last for 10–30 mins. These intensity oscillations could be related to the impulsive motions at the photospheric level. The clear presence of a blue-shift indicates an upward propagating wave. The observed 4–5 min network oscillations can be interpreted in terms of longitudinal magneto-acoustic sausage waves propagating upwards along thin magnetic flux tubes. Kink waves can be generated by random foot-point motions at the photospheric level. As they propagate within flux tubes, their amplitude grows exponentially with height and become non-linear, thereby undergoing a mode transformation becoming sausage waves, which are detected on the disk.

References